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ABSTRACT

This paper reports on recent research in human-computer interactions, gives examples of some of the most promising uses of educational technology, and categorizes the effective and ineffective applications. The purpose of this paper is to provoke discussion about the problems and the potential benefits of computer use among young people. With a focus on the elements of audience, interactivity, and creative integration, the paper discusses the educational possibilities offered uniquely by the computer, arguing that the computer's greatest potential--its ability to draw out students' creativity--is being neglected. The discussion begins by acknowledging the down-side to computer-enhanced learning. The purpose is not to argue for the abandonment of educational technology, but to encourage a more tempered view. The next section proposes types of computer activities that may be particularly valuable for college-level students. Examples of promising educational technology applications are given, and the development of some original material relating to this topic is described. The paper concludes with some personal reflections from a parent's perspective. (AEF)

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Computer-Enhanced or Computer-Enchanted?
The Magic and Mischief of Learning With Computers

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Abstract: What is it about computers that makes them so hypnotic? How can we educators take advantage of the computer's power to attract and hold our students' attention? How can we ensure that our students are creatively engaged in learning, not merely mesmerized by swirling images and button-pushing? Is the computer wasting our students' time more than it is enriching them? This paper will report on recent research in human-computer interactions, give examples of some of the most promising uses of educational technology, and categorize the effective and ineffective applications. With a focus on the elements of audience, interactivity, and creative integration, we will discuss the educational possibilities offered uniquely by the computer, arguing that we are neglecting the computer's greatest potential that is, its ability to draw out our students' creativity.

Introduction

A Mother's View

My son Jonathan got a 3-dimensional puzzle for Christmas a few years ago. It was a 12 X 14 X 4 inch wooden box with a maze inside. The maze was built on a moveable platform, and you could tilt the box back and forth in an effort to get a little silver ball to roll through until it dropped out some hole. Holes closer to the end were worth more points. My son played with the gadget for about an hour, off and on. He has hardly touched it since.

I think that was the same year my son was introduced to PacMan on the computer. You all remember PacMan. A circle with a triangle mouth cut out on the side moved through a 2-dimensional maze, eating colored pellets while being chased by "ghosts." The more pellets your PacMan ate, the more points you got. Jonathan played PacMan for hours, day after day.

What was the difference? Why was one of these activities so absorbing, and the other of such limited interest? Admittedly, my son is just one case, and perhaps his puzzling preferences don't apply to your child or your students. But it represents a trend that's all around us the proclivity of young people for electronic activities, their willingness to sit mesmerized for hours in front of a computer or video screen, when equal time concentrating on almost anything else would be unimaginable. If we could just get at this, if we could figure out exactly what it is that draws so many of them in so magnetically, educators and parents would have a powerful force within their grasp.

The Purpose of this Paper

The purpose of this paper is to provoke discussion about the problems and the potential benefits of computer use among young people. We begin our discussion in section two ("The Bad News") by

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acknowledging the down-side to computer-enhanced learning. Our purpose is not to argue for the abandonment of educational technology, but to encourage a more tempered view. To this end, we attempt to analyze what makes computers so attractive and absorbing with an eye to harnessing them for better purposes. Section three ("The Good News") continues by proposing types of computer activities that may be particularly valuable for college level students. We give examples of promising applications of educational technology and describe some original material developed by the authors and their collaborators. We conclude with some personal reflections from a parent's perspective.

The Bad News

Far more has been written about the wonders of computer-enhanced learning than about the time wasted in front of the computer screen. The reasons are pretty clear. Those who don't care to use computers in their teaching may grumble in the halls about all the money and attention thrown at technology, but they generally don't write about it. On the other hand, the defenders of educational technology often have a vested interest that makes them reluctant to speak out in ways that seem contrary to their own professional commitments – for example, large investments in educational technology at their institutions, or publications in computer-enhanced learning that would be devalued if the field were repudiated. Nevertheless, it is important that those who believe in the potential of educational technology speak out clearly about its disadvantages as well. With a growing number of schools requiring that their students have computers, we have a responsibility to consider carefully how young people are spending time with the companion we have assigned to them.

In the face of the great enthusiasm for computer-enhanced learning, a backlash against the hype was inevitable, and in the past few years some notable books and articles have begun arguing for a more balanced view. Clifford Stoll in *Silicon Snake Oil* was one of the first to proclaim that the emperor had no clothes (Stoll 1995). Focusing primarily on our fascination with the Internet, Stoll warns, "You're viewing a world that doesn't exist. During that week you spend online, you could have planted a tomato garden, volunteered at a hospital, spoken with your child's teacher, and taught the kid down the block how to shag fly balls." His equation speaks the simple, disturbing truth. "Every hour that you're behind the keyboard is sixty minutes that

In a 1999 report, the Kaiser Family Foundation added up the hours and gave us the facts with regard to our children (Kaiser Family Foundation 1999). Surveying 3155 young people between the ages of 2 and 18, they found that on the average 5 ½ hours of a child's day is spent using media (including TV, video games, music, and computers). Nearly 70% of children have a computer in their home, and 45% percent have Internet access. On a typical day, 42% percent of these children will use their computer. When asked to choose the companion they would most like to have if they were stranded on a desert island, children generally prefer computers over TVs, CDs, tapes, radios, video movies, and video games.

Many parents would consider this good news. Computers are viewed as educational -- less passive and more enriching than television. But what are our young people doing during those hours at the computer? The Kaiser study reports that 60% of their time on the computer is devoted to games, email, Web browsing, and chat rooms, while only 22% percent is spent on schoolwork. For boys, shoot-em-up games like Doom or Duke Nukem are much preferred over educational programs.

Our greatest care should be toward the young children, who are being deeply influenced by electronic media at early stages in their development. In 1999, a group of concerned educators, physicians, psychologists, scientists, and philosophers founded the Alliance for Childhood, pooling their expertise in a study of the effects of computers on children (Alliance for Childhood 2000). Their results are well-researched and compellingly conveyed. They describe what many parents and educators have themselves observed – that "young students often seem to be mesmerized by, and some even addicted to, the action on their [computer] screens, rather than motivated to learn." Educational psychologist Jane Healy notes that today's children nurtured on swirling, colorful, quickly-changing, and instantly accessible electronic images -- often find it hard to exercise their own imaginations. (See also Healy 1998.) The report warns that computer use can undermine the sense of wonder and reverence that children typically bring to their encounters with the real world of pebbles, streams, mud, insects, and stars. "What happens to the capacity for quiet wonder," they ask, "when children are regularly bombarded with cartoonish graphics that are far louder and flashier than the real thing, or sanitized, edited versions of reality that don't give them a chance to get their hands dirty?" Nature needs to be approached by young people not as some virtual reality, but as its "raw, untidy self."

The report arrives at the same conclusion drawn by Todd Oppenheimer in his 1997 *Atlantic Monthly* article, "The Computer Delusion" (Oppenheimer 1997): We are spending too much money in our public schools on computer technology without questioning carefully enough the premise that computers serve our children's educational needs. Convincingly, they call for a restriction of the computer's influence and more time with hands-on learning, nature, language, the arts, imaginative play, and most importantly, direct contact with caring adults.

What about college levels students? Are their educational needs being compromised as well? A growing number of universities are insisting that students be equipped with computers as they enter their freshman year. College students have passed through the crucial early developmental stages of their education, and we expect that they now have the maturity to benefit from the computer as an educational tool. But how are they really spending their time on the computer, and how can educators guide them to toward enriching rather than time-wasting activities? Our own experience with university students indicates that they are spending long hours exchanging email and instant messages, browsing the Web, playing games, and -- perhaps the biggest time consumer -- downloading games and music files. Much less time is spent on educational computer activities. Clearly, computers continue to have their hypnotic effect on many college age students. Perhaps if we understood better what attracts them so intensely, we might put that power to better use.

As a point of discussion and a call to further research, we offer our own analysis of the reasons behind the computer's mesmerizing hold on young people. This list emerges only from personal observation, but it may help us to separate what enriches young computer users from what merely panders to them, and guide us more clearly to our educational goals.

Picture a young student focused for hours on a computer screen playing a game. What is it that holds the student's attention so tightly? We see eight factors:

- a feeling of power and control at the push of a button
- competition
- frequent and quick feedback
- incremental successes and rewards
- instant gratification
- visual and auditory stimulation
- little physical exertion
- simple problem-solving, requiring relatively undemanding intellectual exertion

Web browsing shares many of the same attractions, but with the added element of readily accessible information, and without the element of competition. In the case of email and instant messaging, we see the following enticements:

- easy accessibility of friends
- the novelty and mystery of communication with strangers
- the comfort of anonymous or faceless communication
- the ease of informal communication, often in a fun, shorthand slang peculiar to young computer users
- the ease of capricious communication, less restricted by timing and convention (i.e., one can initiate, respond, or not respond to a message at whim)

As for the hours spent downloading games and music files, there is the natural attraction of young people for the popular music and games themselves, the delight of acquiring things free of charge, and the feeling of power and control at the touch of a button.

These attractions are enough to keep many young people tied to a computer for hours a day. But if this list matches your own observations, you would have to agree that computers are not speaking to our students' deepest intellectual selves. How can we tap into these enticements and help guide them toward greater challenges and richer human experiences?

The Good News

This entanglement with educational technology is a Faustian bargain, warns Neil Postman in *The End of Education* (Postman 1995). And yes, we agree that our relationship with computers comes at a high price, but we need not sell our souls in the bargain.

In spite of the acknowledged pitfalls of computer use among young people, we believe that college educators are *not* selling out by requiring that every student have one of these infernal devices. There is enough essential utility in computers to justify them even if their use goes no further than email exchanges with professors, communication among classmates for collaborative work, word processing, and basic Web research. Ensuring that all students have computers is hardly more unusual than ensuring that they all have telephones.

The challenge of educators is to help students become more aware of their habits; talk with them about the pervasive influence of technology in their lives; frequently point them back to the messy, disorganized real world that won't be changed with the click of a mouse; and focus them on computer activities that may truly develop their problem-solving skills, expand their world view, and foster their creativity.

We must consider both what attracts young people to computers as well as the unique capabilities that computers add to the educational environment, and pull the very best out of this mix. With this purpose in mind, we offer the following classification of promising computer activities.

Rote Learning, Exercises, and Mastery of Information or Procedures

Multimedia presentations and on-line exercises will never be a good substitute for the explanations and guidance of a talented human teacher, but they are an excellent supplement. Subjects such as foreign language, medicine, mathematics, and biology require a great deal of time outside the classroom in drill and exercise. Concepts, facts, and phenomena can be vividly conveyed and well-reinforced through a computer -- building an electrical circuit, exploring visual allusions in the political cartoons of Thomas Nast, examining products of linear transformations, watching a 2D harmonic wave disturbance, experimenting with Fermat's principle, designing a snowflake pattern, witnessing a cytoplasm egg donation, or solving a mystery in French, for example. (Excellent Web sites offering exercises such as these include Learner.org at www.learner.org; Exploratorium at www.exploratorium.edu; ExploreScience.com at www.explorescience.com; 7stones at www.7stones.com, and – as one example among the host of foreign language resources – "Apprendre le francais avec l'inspecteur Duflair" at www.polarfle.ovh.org.)

But what of the warnings against multimedia learning that we hear from both Clifford Stoll and Jane Healy? Stoll cautions against the Sesame Street approach, where students are taught by means of cartoons, gaudy numbers, and weird random noises, all of which are highly entertaining but give children the impression that they can learn "without work and without discipline." Similarly, Healy warns of sugar-coated learning that may "spoil children's appetite for the main course," cheating them out of the joy of mastery that comes from hard work and real challenges.

There is truth to what they say, but perhaps they overstate the case. Audio/visual presentations need not be flashy to be effective, and they take advantage of the interactivity that young people enjoy. It is far more engaging to be able to select activities and see immediate feedback than to watch a non-interactive TV-program-style production. When used as a supplement to rather than a replacement for classroom instruction, multimedia exercises and presentations are clearly beneficial.

Activities That Couldn't Be Done Otherwise, Or That Are Done Better With Computers

Computers are not a good substitute for real-world experience. However, they are valuable tools for activities that couldn't be done otherwise, or for activities that are done better with computers. These include

- *Communication that would otherwise be difficult or impossible, such as long-distance conversations among students of different languages and cultures, or student interactions with artists and scholars.* In April of 2000, Secretary of Education acknowledged "The Growing Importance of International Education" and encouraged educators to use the Internet to foster "classroom-to-classroom exchanges that allow young people to learn about each other from each other." Notable initiatives in this area include The Alliance for Global Learning (www.global-learning.org), ePALS (www.epals.com), iEARN (www.iEARN.com), Intercultural Email Classroom Connections (www.teaching.com/iecc), International School Partnerships in Technology sponsored by UNC's Center for International Understanding (www.ga.unc.edu/NCCIU/ispt/), and The Global Schoolhouse (www.lightspan.com).
- *Experiments and demonstrations that are otherwise too dangerous, expensive, or impractical.* Simulations can rarely capture the random, difficult-to-measure elements of natural phenomena, and thus they are second best to real lab experiments. However, for experiments involving entities not visible to the human eye, or materials that are expensive, inaccessible, or dangerous, simulations

provide learning opportunities previously unavailable to students. With the aid of computers, students can now see astronomical views of the night sky from any location at any time; explore microscopic organisms; manipulate molecular structures; "walk through" architectural designs before they have been built; perform autopsies without cadavers; experiment with radioactive materials; or view graphical representations of mathematical functions.

Analysis and presentation of research results closely integrated with the research experiments. A wide range of data capturing and input devices now exist that can be directly interfaced with computers. For example, sound or light waves, radioactive decay, magnetic fields, or temperature can be measured by hardware connected to a computer. Then the data can be analyzed and the results displayed both graphically and numerically within the same computer environment.

Accessibility to information for disabled students or for students at locations distant from learning materials and instructors. On-line learning can minimize the impact of disabilities by delivering learning material directly to disabled students in an accessible format, and allowing these students to reveal their disabilities only if and when they choose. Access to PIVot (http://ncam.wgbh.org/webaccess/pivot) exemplifies the work being done in making multimedia learning material available to students with disabilities. A cooperative effort of MIT, CPB, the NSF, and Mitsubishi Electric American Foundation, PIVot (which stands for Physics Interactive Video Tutor) provides alternative graphical user interface devices for blind and deaf students. For students whose handicap consists solely in their isolation from educational material, the computer is an equally powerful support. For example, *The Power of the Internet for Learning: Moving from Promise to Practice*, a publication of the Web-Based Education Commission, tells of bringing on-line educational material to isolated native Indian communities behind Arizona canyon walls. These examples represent educational opportunities provided uniquely by computer technology.

Logical Problem Solving with Intelligent Tutoring

Computers are built to be logical, and they are less prone to error than humans. It is no surprise, then, that they make excellent tutors in logical problem solving. Moreover, "intelligent" tutors can give well-targeted feedback based upon the student's current mastery level. Progress in artificial intelligence has augmented the computer's fundamental logic, giving it greater "creativity" in finding its own way to solutions. A single computer program can now be written so that it solves not just a single logical problem, but a whole class of problems – even to the extent of proving theorems in formal logic. To go a step further, the computer, equipped with basic problem solving ability, may "learn" better strategies of problem-solving over time. This opens the intriguing possibility of the human and the computer learning interactively and with each other's help.

We have been exploring human/computer interactive learning in our own research.[1] PLogic Tutor is a tutorial program designed to teach students the fundamentals of prepositional logic, including theorem-proving (http://www.cs.wfu.edu/~burg/).[2] The goal of the project is to test the efficacy of tutorial programs that combine intelligent tutoring in the traditional sense (i.e., a tutor that monitors student activity and gives customized feedback) with intelligence in the machine learning sense (i.e., a tutor that learns better problem solving, and thus better teaching strategies, over repeated tutorial sessions).

The computer's application to logical problem solving is natural and full of potential. Educators are well-advised to consider the existing software for development of problem solving skills, as well as pursue open research questions regarding how humans learn logical thinking and how their learning might be enhanced with their ultimately-logical companion, the computer.

Creative Expression

The greatest untapped potential of computers lies in their ability to foster creativity. We have heard the warnings of educational psychologists who observe decreased imagination in students sated on computer use. But this need not be the case if computer use if both limited and channeled.

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[1] We would like to acknowledge the contributions of John Daniel, Alan Levicki, and Stacy Lukins to the PLogic Tutor research project.

[2] Click on PLogic Tutor link at this site. If a login window appears, type in user name *anonymous* and password *plogic*.

Computers *can* encourage creativity. Perhaps the most powerful stimulant to creativity produced by technology is the world-wide audience that it opens up to anyone with something to share. There are few Emily Dickinson's among us, content to slip our poems quietly into a drawer. Art in any medium is a personal expression meant to be shared and appreciated. The World Wide Web – where students can post their writing, music, and art for international view – can motivate students with the possibility of an audience, and this is a stimulant that educators should drawn upon.

Computers also give us powerful and easy-to-use tools for work in a variety of media. Beginning with word processors for writing, we now have progressed to sound editors, MIDI keyboards, CAD programs, photo-editing software, paint programs, virtual reality authoring tools, and multimedia programming languages.

Computer-generated art integrates various media and senses in a novel way that distinguishes it from traditional art. Combining multimedia and interactivity, computers are more than TV screens at close view. Rather, they give rise to a new art form – one with a unique, still-evolving vocabulary, and calling upon a mindstyle different from those inclined toward fine arts as we have previously known them. Computer-generated multimedia art has an appeal for the mathematically and scientifically inclined, and gives them an outlet for creative expression that they may not experience otherwise. It can be the meeting place of the Gödels, the Eschers, and the Bachs.

In addition to giving students a new mode of creative expression, original computer-generated works can add dimension to a student's experience of traditional art, music, or literature. For example, consider how a student's understanding of a poem might be enriched by an interactive multimedia interpretation, one in which the resonances of a word's interpretations are represented through a vocabulary of hyperlinks, fade in/out, cursor navigation, visual and auditory metaphors, etc. A new form of literary criticism, or a mixture of criticism and creative interpretation through interactive multimedia, opens intriguing possibilities.[3] The enrichment of artistic discovery via computer technology is well worth considering if we hope to tap into the creative reserves of our technologically-inclined students.

A Mother's View, Revisited

My son is 13 now, and he still would like to play at the computer more than I think he should. He has gone on to flashier, more complex games that have him building empires or searching out and destroying superhuman foes. I don't think there's much in these games to challenge his intellect, but nonetheless he can sit absorbed in them for hours. I'm encouraged, however, that there do exist computer-based activities for young people that can engage their interest as well as develop their creativity. Allow me to give an example from my parental perspective.

Last year, Jonathan was required to do an artistic composition for a school project. He chose to do music. His first efforts to compose a song at the piano were simple and child-like – smudged scribblings of alphabetic notes on a dog-eared scrap of paper. From there, he transcribed his song by hand into proper musical notation – still smudged and elementary, but with a few embellishments that came to him as he notated the score. It was then that he learned that he could get a trial version of a musical transcription computer program. Now Jonathan could "type" the musical score into the computer and print it out in perfect form. This basic computer tool made it much easier to note and play back the music. I watched with fascination as my son cut and pasted, made variations, and finally emerged with a piece so complex and interesting that his own fingers could hardly keep up with it any more. This, I thought, was time well-spent on the computer.

Jonathan still prefers empire building and superhuman foes. But I keep hoping that my young technophile – this used-to-be-little boy who always drew people as geometric shapes and lulled himself to sleep murmuring number patterns – will eventually be drawn to deeper intellectual and creative challenges, if I just keep laying them in his path. That's my job as a parent. That our job, as educators.

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[3]We will explore the topic of "Creative Multimedia Expression and Interpretation" in the October 2001 issue of *The IMEJ of Computer-Enhanced Learning*, http://imej.wfu.edu, and a First-Year Seminar on "Invention and Interpretation: A Multimedia Approach to Literature " will be offered at Wake Forest University in the spring of 2002.

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